Cambridge Assessment International Education

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CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **0620/33**

Paper 3 Theory (Core) **May/June 2021**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **16** pages.

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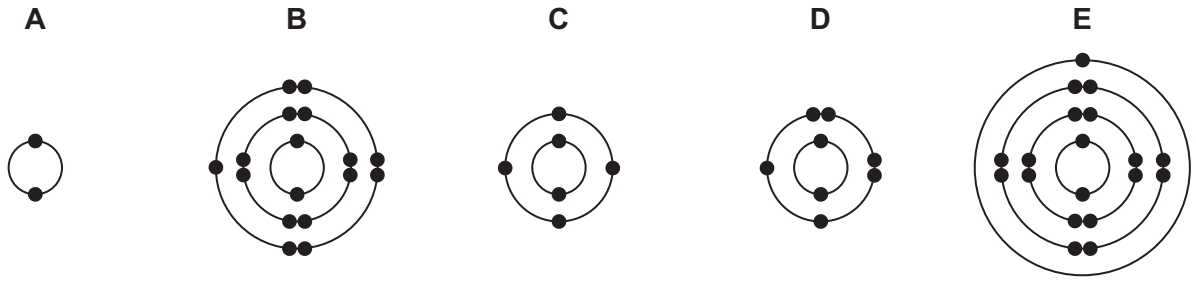
1 **(a)** The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.

View solution



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom of an element in Group VI of the Periodic Table

..... [1]

(ii) an atom of a reactive metal

View solution

..... [1]

(iii) an atom with a proton number of 17

View solution

..... [1]

(iv) an atom that forms a stable ion with a charge of 2–

View solution

..... [1]

(v) an atom of oxygen.

View solution

..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the bromine atom and fluoride ion shown.

View solution

	number of electrons	number of neutrons	number of protons
$^{81}_{35}Br$	35		
$^{19}_{9}F^-$		10	

[3]

[Total: 8]

2 The table shows the masses of some of the ions in 1000 cm^3 of fruit juice.

name of ion	formula of ion	mass of ion in 1000 cm^3 of fruit juice / mg
ammonium	NH_4^+	6
calcium	Ca^{2+}	73
chloride	Cl^-	238
magnesium	Mg^{2+}	77
	NO_3^-	10
phosphate	PO_4^{3-}	20
potassium	K^+	419
	Na^+	3
sulfate	SO_4^{2-}	10

(a) Answer these questions using only the information in the table.

View solution

(i) State which negative ion has the highest mass in 1000 cm^3 of fruit juice.

..... [1]

(ii) Give the formulae of the ions in sodium nitrate.

View solution

..... and ..... [1]

(iii) Calculate the mass of ammonium ions in 250 cm^3 of fruit juice.

View solution

mass = ... mg [1]

(b) Describe a test for chloride ions.

View solution

test .....

observations .....

[2]

(c) Phosphate ions, PO_4^{3-}, are present in most fertilisers. Phosphate ions contain phosphorus.

View solution

(i) State the names of two **other** elements that are in most fertilisers.

1 .....

2 .....

[2]

(ii) Explain why farmers put fertilisers on fields where crops are to be grown.

.....

..... [1]

View solution

(d) A student heated ammonium sulfate with sodium hydroxide in a test-tube.

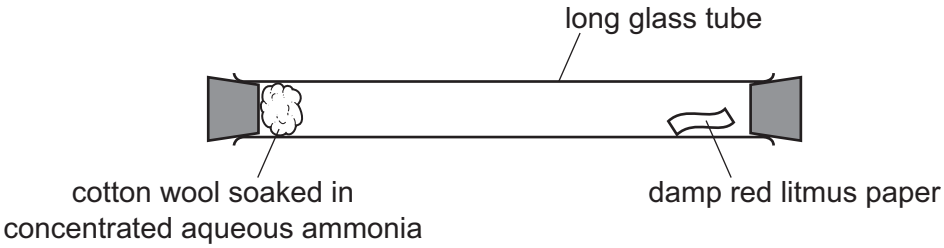
(i) Complete the equation for this reaction.

$(NH_4)_2SO_4 + ...NaOH \rightarrow .....NH_3 + Na_2SO_4 + 2H_2O$ [2]

View solution

(ii) Concentrated aqueous ammonia releases fumes of ammonia gas.

A long glass tube is set up as shown.



At first, the red litmus paper does not turn blue.
After a short time, the litmus paper turns blue.

Explain these observations using the kinetic particle model.

.....

.....

.....

.....

..... [3]

[Total: 13]

3 The table shows some properties of five halogens.

element	melting point / °C	boiling point / °C	density of liquid at boiling point in g / cm^3	colour
fluorine	–220	–188		yellow
chlorine		–35	1.56	light green
bromine	–7	59	3.12	red-brown
iodine	114	184	4.93	dark grey
astatine	302	337	6.35	

(a) (i) Complete the table by predicting:
- the melting point of chlorine
- the density of liquid fluorine at its boiling point
- the colour of astatine.

View solution

[3]

(ii) Deduce the state of bromine at 0 °C.
Explain your answer.

View solution

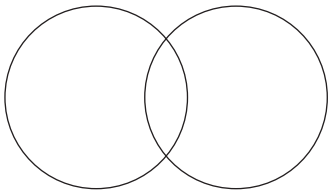
.....

.....

..... [2]

(b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of chlorine.
Show the outer shell electrons only.

View solution



[2]

(c) (i) Astatine is a radioactive element.

View solution

An isotope of astatine, $^{217}_{85}At$, decays to form an isotope of bismuth, $^{213}_{83}Bi$.

Describe what happens to the number of nucleons during this decay.

..... [1]

(ii) One of these statements about isotopes is **incorrect**.

View solution

Tick the box with the incorrect statement.

The isotope ^{235}U is a source of energy.	☐
Some radioactive isotopes can be used to treat cancer.	☐
All isotopes are radioactive.	☐
Isotopes of the same element have the same number of protons.	☐

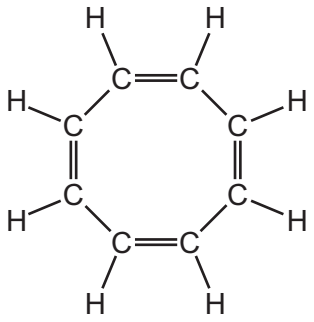
[1]

[Total: 9]

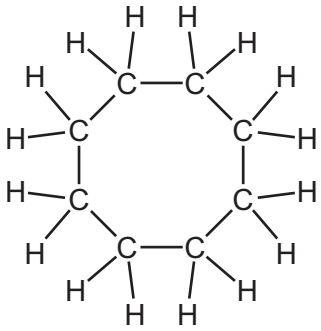
4 **(a)** The structure of two organic compounds, **F** and **G**, are shown.

View solution

F



G



(i) Compound **F** is an unsaturated compound.

Describe a chemical test for an unsaturated compound.

test .....

observations .....

[2]

(ii) Compound **F** is reduced to compound **G** using hydrogen and a catalyst.

View solution

State what is meant by the term *catalyst*.

.....

..... [1]

(iii) Compound **G** is a saturated hydrocarbon.

View solution

Name the saturated hydrocarbon which contains two carbon atoms.

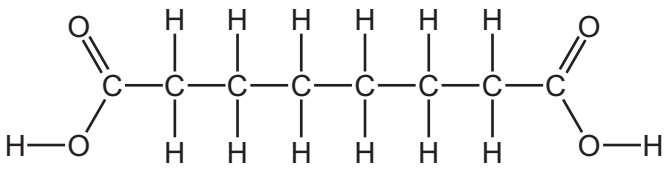
..... [1]

(b) Compound **G** is oxidised by nitric acid to compound **H**.

View solution

The structure of compound **H** is shown.

H



(i) Deduce the formula of compound **H** to show the number of carbon, hydrogen and oxygen atoms.

..... [1]

(ii) Compound **H** contains two carboxylic acid functional groups.
Ethanoic acid also contains a carboxylic acid functional group.

View solution

Draw the structure of ethanoic acid. Show all of the atoms and all of the bonds.

[1]

(iii) Describe the observations made when ethanoic acid reacts with:

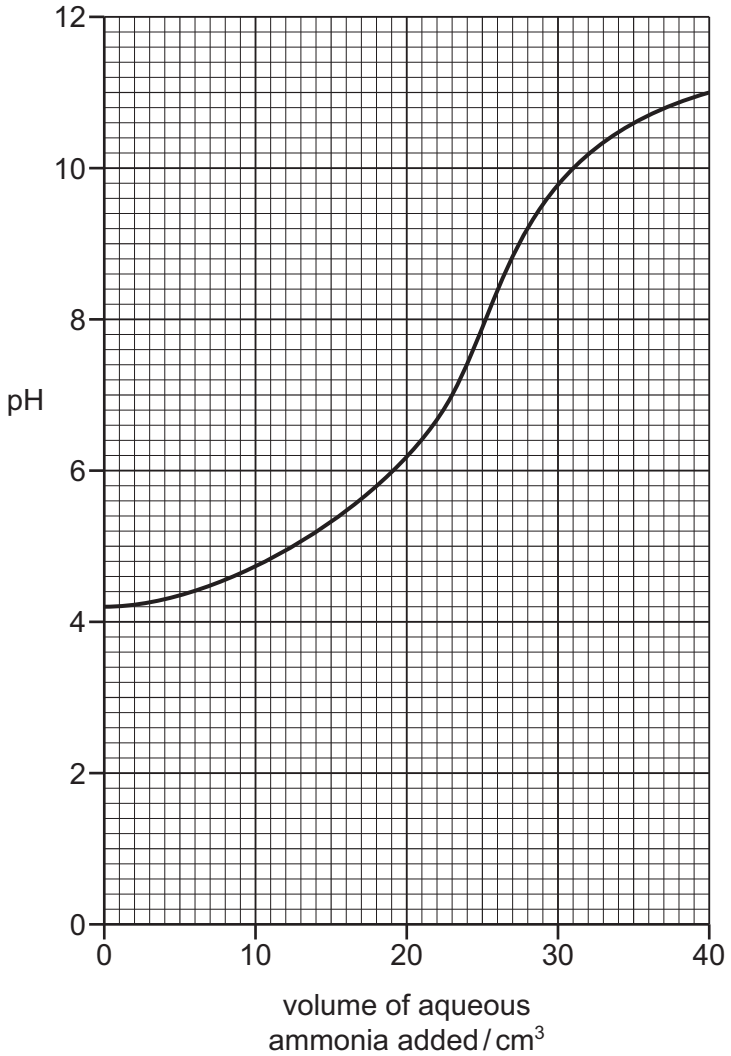
View solution

universal indicator solution .....

sodium. .....

[2]

(c) A student's graph of how the pH changes when aqueous ammonia is added slowly to dilute ethanoic acid is shown.



(i) Deduce the pH of the dilute ethanoic acid before the addition of aqueous ammonia.

View solution

pH = ... [1]

(ii) Deduce the volume of aqueous ammonia added when the pH is neutral.

..... cm^3 [1]

(d) Compound **H** reacts with compound **J** to form a polymer.

View solution

Compound **J** has the formula $HOCH_2CH_2OH$.

(i) State the name of the –OH functional group in compound **J**.

..... [1]

(ii) Ethene polymerises to form poly(ethene).

View solution

Choose **one** word from the list that best describes the type of reaction that occurs.

Draw a circle around the correct answer.

addition **combustion** **cracking** **reduction** [1]

[Total: 12]

5 **(a)** Cement is made by heating a mixture of calcium carbonate and powdered clay.

View solution

(i) Choose from the list the name of the substance which contains calcium carbonate.

Draw a circle around the correct answer.

bauxite **hematite** **limestone** **slaked lime** [1]

(ii) The heat for this process is provided by burning natural gas.

View solution

Name the main constituent of natural gas.

..... [1]

(b) Complete the word equation for the thermal decomposition of calcium carbonate.

View solution

calcium carbonate	→	....	+	....

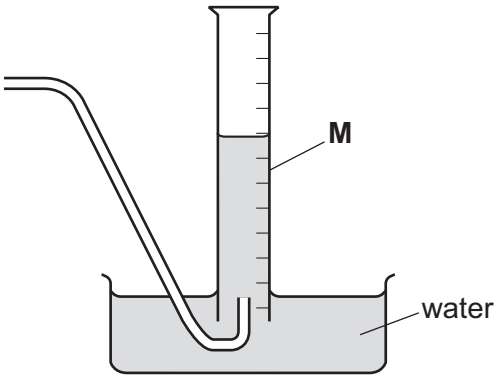
[2]

(c) Carbon dioxide is produced when dilute hydrochloric acid reacts with powdered calcium carbonate.

View solution

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

(i) Complete the diagram to show the apparatus used to investigate the volume of carbon dioxide produced during this reaction.



[2]

(ii) Name the piece of apparatus labelled **M** in the diagram.

..... [1]

(iii) Suggest the name of another piece of apparatus that can be used to measure the volume of carbon dioxide produced.

..... [1]

(iv) Describe the effect of each of the following on the rate of reaction of dilute hydrochloric acid with calcium carbonate.

- Large pieces of calcium carbonate are used instead of powdered calcium carbonate.

All other conditions stay the same.

.....

- The temperature is decreased.

All other conditions stay the same.

.....

[2]

(d) Explain how carbon dioxide contributes to climate change.

View solution

.....

.....

..... [2]

[Total: 12]

6 This question is about air.

(a) State the percentage of nitrogen in clean, dry air.

View solution

..... % [1]

(b) Clean, dry air also contains argon. Argon is unreactive.

View solution

(i) Explain, using ideas about electronic structure, why argon is unreactive.

.....

..... [1]

(ii) Give **one** use of argon.

View solution

..... [1]

(c) Carbon monoxide and oxides of nitrogen are pollutants of air.

View solution

For each of these pollutants state the source of the pollutant and an adverse effect of the pollutant.

source of carbon monoxide .....

adverse effect .....

source of oxides of nitrogen .....

adverse effect .....

[4]

[Total: 7]

7 Concentrated hydrochloric acid is electrolysed using carbon electrodes.

(a) State the products of this electrolysis at:

View solution

the negative electrode .....

the positive electrode. .....

[2]

(b) Name a metal that can be used as an inert electrode instead of carbon.

View solution

..... [1]

(c) When dilute sulfuric acid is electrolysed, oxygen is produced at the positive electrode.

View solution

(i) Describe the separation and motion of the molecules in oxygen gas.

separation .....

.....

motion .....

.....

[2]

(ii) Describe a test for oxygen.

View solution

test .....

observations .....

[2]

[Total: 7]

8 This question is about elements in the Periodic Table.

(a) The table shows some properties of five elements, **P**, **Q**, **R**, **S** and **T**.

View solution

element	melting point / °C	density in g / cm^3	electrical conductivity of the solid	atomic radius / nm
P	114	4.93	does not conduct	0.133
Q	1083	8.92	very good	0.117
R	3550	3.51	very good	0.077
S	1495	8.9	very good	0.121
T	248	1.2	does not conduct	0.065

Use only the elements shown in the table to answer these questions.

State which two of the elements, **P**, **Q**, **R**, **S** and **T**, have covalent molecules.
Give **two** reasons for your answer.

elements ..... and .....

reason 1 .....

reason 2 .....

[3]

(b) Diamond is a form of solid carbon.

View solution

(i) Describe the structure and bonding in diamond.

.....

..... [2]

(ii) State why diamond is used for cutting tools.

View solution

..... [1]

(iii) Name one **other** form of solid carbon.

..... [1]

View solution

(c) Lithium is an element in Group I of the Periodic Table. Copper is a transition element.

View solution

Copper has a higher melting point and higher boiling point than lithium.

Give **two** other ways in which the properties of transition elements differ from the properties of Group I elements.

.....

..... [2]

(d) State whether lithium oxide is a basic oxide or an acidic oxide.
Give a reason for your answer.

View solution

..... [1]

(e) The table compares the reactions of four metals with steam.

View solution

metal	reaction with steam
copper	does not react
iron	reacts rapidly at 120 °C
lithium	reacts very rapidly at 120 °C
nickel	only reacts above 800 °C

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive → most reactive

[2]

[Total: 12]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).